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POLYMERIC GARMENT MATERIAL

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This invention relates to polymeric garment material, garments and methods of making polymeric garment material.

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Polymeric materials are currently used for a wide range of garments, some of these garments (for example, raincoats and aprons) make use of the protective properties of the material, other garments (for example, footwear, underwear and fashion garments) use polymeric materials because of appearance and/or feel of the material.

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Figure 1 illustrates the steps of a known method of producing a knitted nylon garment that has a polyurethane (PU) coating. At step 10 a knitted nylon lining is fitted on to a mould. The nylon lining acts as a substrate to which the PU coating is applied. Figure 2 illustrates a sock lining 32 fitted to a mould 30 that supports the lining 32 so that the lining 32 takes the desired shape for the finished garment. In the case illustrated the garment is a sock, however, the method is applicable to other garments. At step 12 the mould 30 (fitted with the sock lining 32) is immersed into a solution of PU and dimethylformamide (DMF). At step 14 the mould 30 is withdrawn from the solution of PU and DMF and excess solution is allowed to drain leaving a coating of the PU/DMF solution on the lining 32. At step 16 the mould is immersed in water. The immersion causes the PU coating on the lining 32 to coagulate, that is the PU coating sets. The mould 30 remains in the water for a period of 90 to 120 minutes so that the DMF solvent is leached out of the lining into the water. At step 18 the mould is removed from the water and placed in an oven to dry the PU coated nylon liner. Finally at step 20 the PU coated nylon liner is removed from the mould 30 and a PU coated nylon sock is obtained.

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A major disadvantage with this process is that it uses DMF. DMF is a solvent that is known to be very toxic, and one that is easily absorbed

through the skin. Therefore great care has to be taken when handling the solution of PU/DMF. In order that a safe working environment is provided the atmosphere in which the process is carried out needs to be well ventilated and provided with extraction fans.

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At step 16, when the DMF is leached into water, the water will become saturated with DMF. Therefore, the water will need to be repeatedly changed - this is both time consuming and expensive. Additionally, since the DMF saturated water solution is toxic, care must be taken when
10 disposing of the DMF saturated water so as to minimise environmental damage that may occur from the disposal.

An alternative to DMF is the use of THF (Tetra Hydro Furan). However THF is also a noxious chemical and has many of the disadvantages
15 associated with DMF.

A further disadvantage of the process is that the PU coating penetrates the interstices of the nylon liner. Therefore, the PU coating will come into contact with the skin of a wearer of a garment made by this process if such
20 a garment is worn next to the skin. This can cause irritation and build up of perspiration next to the skin, and, in particular, some wearers may be allergic to PU. Skin irritation may also be caused by any DMF or THF that has not been removed during the leaching step 16. DMF in particular is readily absorbed through the skin. A further hazard of DMF is that it is
25 known to be carcinogenic and to be the cause of foetal defects.

According to a first aspect of the invention there is provided a method of making garment material, the method having the steps: applying coagulant to a substrate; applying a foam of the polymeric material to the substrate;
30 allowing the coagulant to coagulate some of the foam; and removing uncoagulated foam from the substrate to leave a layer of coagulated polymeric material on the substrate.

The use of foamed (aerated) polymeric material removes the need for the polymeric material to be dissolved in DMF, THF or, indeed, any other solvent. Therefore, the method is less hazardous and more environmentally friendly. The garment material produced by the method will not contain potentially harmful traces of solvent.

A wide range of polymeric materials are suitable for production of the foam, these include nitrile latex, natural latex, polyvinylchloride (PVC), polyvinylacetate (PVA) neoprene (polychloroprene) and rubber as well as PU latex. The foam may be produced from one of or a blend of two or more of these polymeric materials. Hence, the method provided by the invention is more widely applicable than the known method (illustrated in Figure 1), which is restricted to the use of PU.

The substrate may be, for example, knitted nylon but a wide range of materials may be used as the substrate, for example, the substrate may be one of, or a blend of two or more of: cotton, spandex, lycra, polyester, aramid, dyneema, acrylic, carbon conductive fibre, copper conductive fibre, thunderon conductive fibre, multifilament yarn spun from liquid crystal polymer (available under the brand name Vectran™), tactel, CoolMax™, ThermaStat™, Thermax™ and Viafil (RTM). For example, the substrate may be a blend of nylon and lycra and may comprise a blend of 95% nylon and 5% lycra. Such a blend is particularly comfortable to wear, the garment conforming well to the shape of the wearer.

Preferably, the step of removing the uncoagulated foam comprises directing a fluid at the substrate. For example a spray of liquid such as water may be directed at the substrate.

Surprisingly, this method of removing the excess, uncoagulated foam leaves behind a cohesive, porous and breathable layer of polymeric material

on the substrate. A garment made from the garment material produced in this way allows perspiration to escape from the wearer of the garment and reduces heat build up within the garment.

- 5 The garment material is more flexible and lightweight and garments made from the garment material are more comfortable to wear than garments produced by the prior art method illustrated in Figure 1.

10 The penetration of the foam into the substrate may be controlled so that the foam does not fully penetrate the substrate. In this way, the garment material produced has an inner surface that does not have exposed polymeric material. This is advantageous since many people have an allergic reaction to polymeric materials (especially latex) worn next to the skin and the non-penetrated portion of the substrate forms a barrier between
15 the wearer of the garment and the coating of the polymeric material. The risk of further skin irritation caused by solvents such as DMF and THF is also removed since this process removes the need for such solvents. This is particularly important as DMF is readily absorbed through the skin and is known both to be carcinogenic and to cause foetal defects.

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According to a second aspect of the invention there is provided garment material produced by the method of the first aspect of the invention.

25 According to a third aspect of the invention there is provided a garment produced by the method of the first aspect of the invention.

According to a fourth aspect of the invention there is provided a garment or garment material having a substrate and a layer of coagulated polymeric material penetrating at least partially the substrate, the garment or garment
30 material having a water vapour permeability in the range 3.5 to $6.5 \text{ mg.cm}^{-2}.\text{h}^{-1}$.

According to a fifth aspect of the invention there is provided a garment or garment material having a substrate and a layer of coagulated polymeric material penetrating the substrate, wherein the polymeric material does not fully penetrate the substrate.

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According to a sixth aspect of the invention there is provided a garment or garment material having a substrate and a layer of coagulated polymeric material penetrating at least partially the substrate, wherein the garment or garment material has a water vapour permeability in the range 3.5 to 6.5 mg.cm⁻².h⁻¹. Preferably the garment or garment material has a water vapour permeability in the range 5.0 to 6.5 mg.cm⁻².h⁻¹.

According to a seventh aspect of the invention there is provided a garment or garment material which, when subjected to a temperature of 20± 2 °C and a relative humidity of 65±2% for 265 minutes, will hold between 1.0 mg and 8.5 mg of water per cm² of the garment or garment material.

Preferably the garment or garment material, when subjected to a temperature of 20± 2 °C and a relative humidity of 65±2% for 265 minutes, will hold between 1.0 mg and 5.5 mg of water per cm² of the garment or garment material.

According to an eighth aspect of the invention there is provided a method of applying discrete areas of polymeric coating to the layer of coagulated foam of a garment or garment material produced by the method of the first aspect of the invention. The method may further comprise at least one of the steps of: washing the garment or garment material to remove residue; partially drying the garment or garment material and dressing the garment or garment material on a dot former before applying the polymeric coating; and then curing the dots; and stripping the garment or garment material from the dot former after applying the polymeric coating.

Preferably, the garment or garment material is washed with a solution of water and detergent. The garment or garment material is preferably partially dried at a temperature of around 50-70⁰C. Advantageously, only partially drying the washed garment or garment material so that the dot coating is applied to a damp coagulated polymeric layer improves the bonding between the dots and the coagulated foam.

The dot coating may comprise one of or a blend of two or more of nitrile latex, natural latex, PU latex and latex and preferably has a viscosity of around 100-400 poise.

The dot coating may be cured for 30-45 min at a temperature of 60-140⁰C. Alternatively, the dot coating may be cured in two stages. The first stage may comprise 15-30 min at 60-80⁰C. The second stage may comprise 20-40 min at 120-150⁰C. The dot coating may have a thickness of around 0.2-2.0 mm before curing, which may be reduced to around 0.05-1.0 mm after curing.

According to a ninth embodiment of the invention there is provided a garment or garment material produced by the eighth aspect of the invention.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 schematically illustrates a prior art method of making polyurethane coated garments;

Figure 2 schematically illustrates a substrate that has been placed on a mould;

Figure 3 schematically illustrates a method of making garment material according to an embodiment of the invention;

Figure 4 schematically illustrates a system for making garment material according to an embodiment of the invention;

Figure 5 schematically illustrates a plan view of a flight bar to which several moulds are mounted;

Figure 6 schematically illustrates a side view of the flight bar of Figure 5, the flight bar being translated into a spraying station;

Figure 7 schematically illustrates a side view of a garment substrate in a section of the spraying station of Figure 6 in which nozzles are pointing upwards;

Figure 8 schematically illustrates a side view of a garment substrate in a section of the spraying station of Figure 6, in which nozzles are pointing horizontally; and

Figure 9 schematically illustrates a side view of a garment substrate in a section of the spraying station of Figure 6, in which nozzles are pointing downwards.

Figure 10 illustrates a discrete array of areas of polymeric coating applied to the surface of a garment or garment material produced using the method of Figure 3.

Figure 11 schematically illustrates a method of applying a discrete array of areas of polymeric coating to the surface of a garment or garment material produced using the method of Figure 3.

Figure 12 schematically illustrates a cross section through the garment or garment material of Figure 10.

Referring to Figures 3 and 4, to make a garment according to an embodiment of the invention, at step 210 a lining or substrate 32 is fitted to a mould 30. The mould 30 supports the substrate 32 during the various process steps that are applied to the substrate 32 to produce the garment material. After the garment material has been made it is removed from the mould 30.

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The substrate 32 may take the form of a complete garment, for example, a sock (as is illustrated in Figure 2) or in a form that is a section of a garment, for example a pocket for a coat. In such cases the mould 32 provides the correct shape for the finished garment or garment section. When the mould takes the shape of a finished garment it is preferable that the substrate 32 fitted on to the mould 30 is seamless so that the finished garment is also seamless. Alternatively, the mould 32 need not take any particular form and sheets of garment material are formed by the process. For example, the substrate may be stretched out between two clamps or rollers, and for the purpose of this specification the term "mould" covers arrangements of clamps, rollers and the like that support the substrate 32 by applying tension to the substrate 32. In this case, garment or garment sections are produced by further processing of the sheets of garment material for example by pieces being cut from the sheet of garment material and then the pieces being used to make a garment.

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The mould 30 may be made from, for example, metal, porcelain, fibreglass or plastic.

Suitable materials for the substrate 32 include one of, or a blend of two or more of: nylon, cotton, spandex, lycra, polyester, aramid, dyneema, acrylic, carbon conductive fibre, copper conductive fibre, thunderon conductive

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fibre, multifilament yarn spun from liquid crystal polymer (available under the brand name Vectran™), tactel, CoolMax™, ThermaStat™, Thermax™ and Viafil (RTM). For example, the substrate could comprise a blend of 95% nylon and 5% lycra. The substrate 32 has a lattice structure and may
5 be formed by knitting, weaving or some other known process.

The process may be applied to batches of substrates ('batch-processing) such that the process steps are applied to a group of moulds 30, each mould 30 supporting a substrate 32. Alternatively, the process may be applied
10 continuously such that the moulds 30 are continuously translated through the system 100. Of course, the moulds 30 may be continuously translated through some parts of the system 100 and stationary for periods of time at other parts of the system 100 according to what particular process step is occurring at those positions. Referring to Figure 5, the moulds 30, bearing
15 the substrates 32 are mounted in a row on a bar 50, termed a "flight bar". In the example illustrated, four pairs of moulds 30 (bearing four pairs of gloves respectively) are mounted on a flight bar 50. The flight bar 50 moves in a linear direction from one process station to another at a set speed. Of course, the speed at which the flight bar is set can be varied.
20 There may be several flight bars 50, each flight bar 50 being at a different stage of the process, and the movement of a flight bar 50 from one station to the next is at set intervals.

At step 214 coagulant 34 is applied to the substrate 32. This may be
25 achieved by immersing the substrate 32 (supported on the mould 30) into a bath or trough 36 containing the coagulant 34 or by spraying the coagulant 34 onto the substrate 32. The coagulant 34 is an aqueous or alcoholic solution of electrolytes. Suitable electrolytes include formic acid, acetic acid, calcium nitrate, calcium chloride or a mixture of two or more of these.
30 Ethanol may be used to provide the alcoholic solution of electrolytes but other alcohols are also suitable, for example, iso-propyl alcohol and methanol may also be used.

At step 218 excess coagulant 34, i.e. coagulant that is not absorbed by the substrate 32 is allowed to drain from the substrate 32. If the coagulant 34 was applied by immersion in a bath/trough 36 of coagulant 34 then step 218 involves withdrawal of the mould 30 from the bath/trough 36.

Alternatively, to apply the coagulant to the substrate, the substrate can be pressed onto a sponge saturated with coagulant. This method reduces the amount of coagulant picked up by the substrate, avoiding the need to allow time for excess coagulant to drain from the substrate.

At step 222 a foam 38 of polymeric material is applied to the substrate 32, for example by immersing the mould 30 supporting the substrate 32 into a bath/trough 37 of the foam 38. The production of a foam 38 of polymeric material is well known to a skilled person. The foam 38 may be formed from one of, or combination of, several polymeric materials. Suitable polymeric materials include PU latex, nitrile latex, natural latex, polyvinylchloride (PVC), polyvinylacetate (PVA), neoprene (polychloroprene) and rubber. The foam 38 has a density in the range 15-35%, i.e. there is 15-35 % air by volume in the foam and a viscosity in the range 80-180 poise (8-18 Ns/m²). The foam 38 contains thickeners so that the foam 38 is of the required viscosity. The thickeners are usually added to the polymeric material when the polymeric material is in liquid form, i.e. before it is aerated. Examples of thickeners include polyvinyl alcohol (0.2 - 0.6 parts per 100 parts polymeric material by volume) methyl cellulose (0.2 - 0.8 parts per 100 parts polymeric material by volume) and polyacrylate (0.2 - 0.6 parts per 100 parts polymeric material by volume). The foam also contains stabilisers so that the foam 38 is stable (i.e. does not degrade to a liquid) and curatives that provide the polymeric coating obtained from the foam with mechanical strength so that the coating is resistant to, for example, abrasion, punctures and tearing. The stabilisers and curatives are usually added to the polymeric material when the polymeric material is in

liquid form. Examples of stabilisers include diphenyl guanidine alcohol (with a concentration of about 0.5 parts per 100 parts polymeric material by volume) and alkali casein (0.3 - 0.8 parts per 100 parts polymeric material by volume). Although the thickeners, stabilisers and curatives are normally
5 added to the liquid polymeric material before it is aerated, they can also be added after aeration, for example if modification of the foam properties is required (for example by adding more thickener to increase the viscosity of the foam).

10 At step 226 the substrate 32 is removed from the foam 38 and excess foam is allowed to drain from the substrate 32 to leave a layer of foam 38 on the substrate 32. The foam is arranged, as described in more detail below, not to pass through the substrate 32, but to remain on the outer surface or pass part way through the substrate. The foam therefore forms a layer on the
15 outside of the substrate 32.

At step 228 the foam 38 reacts with the coagulant 34 that has been absorbed by the substrate 32 causing coagulation of the foam 38.

20 Only partial coagulation of the foam 38 is required, therefore, the foam 38 is allowed to react with the coagulant 34 for a limited period of time. After this period of time the foam closest to the substrate 32 will be coagulated but the degree of coagulation progressively decreases with distance from the substrate 32 so that the outer surface of the foam will not be coagulated
25 (i.e., the outer surface will be wet). Typically the foam 38 is allowed to react with the coagulant 34 for a period in the range of 60-180 seconds before the excess (uncoagulated) foam 38 is removed. This period is controlled so that the underside of the foam layer that is in contact with the substrate 32 coagulates, but the outer part of the foam layer does not
30 coagulate. Therefore, a film skin is not formed on the outer surface of the foam layer. The foam layer has a thickness in the range 0.5 - 1.5 mm.

At step 230 the outer layer of excess, uncoagulated foam 38 is removed from substantially the whole area of the foam layer on the substrate 32. This may be done by directing one or more sprays of water 40 at the substrate 32. The water is directed at the substrate 32 via one or more
5 nozzles 42. Each spray of water 40 has a pressure in the range 1 - 4 bar (1×10^5 - 4×10^5 N/m²). The spraying process lasts for about 5 - 20 seconds.

The nozzles 42 may be stationary with a set orientation relative to the substrate 32. Alternatively, the nozzles 42 may be moveable so that the
10 orientation of the nozzle 42 relative to the substrate 32 can be varied during the spraying process. The nozzles 42 may also be translatable relative to substrate 32 during the spraying process to provide good coverage of the substrate 32 with the spray 40. It is also possible to use a continuous jet instead of a spray, however, a spray is preferred since this makes more
15 economical use of water.

Referring to Figures 6 to 9, according to an embodiment of the invention the moulds 30, bearing the substrates 32, are translated on a flight bar 50 to a spraying station 52. Figures 6 to 9 illustrate the substrate 32 in the form
20 of a glove lining with the fingers of the glove lining pointing downwards (of course the invention is applicable to sock linings and other garment substrates). The spraying station 52 comprises a number of spray nozzles 42. The nozzles form two rows 43 that are orientated so that the nozzles of one row sprays the front of the substrate 32 (e.g. the palm side of the glove
25 linings 32) whilst the nozzles of the other row spray the back of the substrate 32 (e.g. the backhand side of the glove linings 32). The nozzles 42 are in a fixed position with a pre-set spraying angle and the nozzles 42 do not move during the spraying process. The spraying angle of each nozzle 42 is in the range 0 to 45° to the horizontal (the horizontal being the
30 normal to the surface of the substrate 32) and the spraying angle may be adjusted before the spraying process. The nozzles 42 may be arranged as pairs with a nozzle 42a on one row facing a nozzle 42b of the other row.

The nozzles 42a, 42b may be set at different angles: for example the pair of nozzles 42a, 42b may point upwards at about 45° to the horizontal as illustrated in Figure 7; the nozzles 42a, 42b may point horizontally as illustrated in Figure 8; or the nozzles 42a, 42b may point downwards at 45°
5 to the horizontal illustrated in Figure 9. It is not necessary for the nozzles 42a, 42b in each pair to be orientated at the same angle to the horizontal.

As water is pumped through the nozzles 42 the flight bar 50 is translated vertically through the spray produced by the nozzles 42. For example, the
10 moulds 30 are first moved downwardly through the sprays and then upwardly through the spray as the moulds are moved through the spraying station on the flight bar 50.

Other fluids could be used to remove the foam 38, for example a jet of
15 compressed air could be directed at the substrate 32. The foam 38 could also be removed by immersing the substrate 32 in a bath/trough of an aqueous medium. The aqueous medium may comprise an anti-foam agent such as an emulsion of organo-modified polysiloxanes in the concentration range 0.01 - 0.1% by volume or a blend of petroleum and amorphous silica
20 in the concentration range 0.2 - 0.8% by volume.

The removal of the excess foam 38, by directing fluid at the substrate 32, leaves behind a cohesive, porous and breathable layer of polymeric material on the substrate 32. At this stage of the process the layer of polymeric
25 material has a thickness in the range 0.34 – 1.0 mm.

At step 232 excess coagulant 34 is removed from the substrate 32. This may be done by immersing the substrate 32 into a bath/trough of water 41; typically the immersion is for a period of about 15 minutes.

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At step 234 the substrate 32 with its layer of polymeric material is dried. The drying may be done in an oven 44 which may be fitted with one or

more fans that distribute the heat evenly throughout the oven 44. The drying could also be achieved by directing air over the substrate 32. The air may be dried and/or heated before it is directed over the substrate 32.

- 5 After being dried, the layer of polymeric material has a thickness in the range 0.26 – 0.80 mm.

At step 236, the garment material, comprising the substrate 32 with the polymeric coating, is removed from the mould 30.

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The garment material produced by the above process has a uniform porosity.

- 15 The penetration of the foam 38 into the substrate 32 can be controlled so that the foam does not fully penetrate the substrate 32. In this way, the garment material produced has an inner surface with no, or very little, exposed polymeric material. This is advantageous since many people are have an allergic reaction to polymeric materials (especially latex) worn next to the skin and the non penetrated portion of the substrate 32 would
- 20 form a barrier between the wearer of the garment and the coating of the polymeric material.

- The penetration of the foam into the substrate (and the porosity of the finished garment material) can be controlled by varying a number of
- 25 parameters including:

- i. the formulation of the polymeric material;
- ii. the formulation of the coagulant;
- iii. the time between applying the coagulant and applying the foam;
- 30 iv. the time between applying the foam and removing excess (uncoagulated) foam;
- v. foam density;

- vi. foam viscosity; and
- vii. the weight and construction of the substrate.

5 The parameter values disclosed in the description provide fabric material that has the desired properties, however, the skilled person may achieve the advantages of the invention using a method having parameters that vary from those given.

10 The garment material produced by the invention is particularly suitable for gloves, for example gardening gloves and gloves used for light assembly (for example the assembly of electronic components). Such gloves (particularly gloves for light assembly) need to provide the wearer with a high degree of dexterity and, when the gloves are worn for a long period of time, the hands need to be kept cool, dry and comfortable. Gloves made by
15 the process of the invention allow perspiration to escape from the glove/be absorbed by the glove and the hands of the wearer are not irritated by the glove (either by heat build up, sweat, solvent residue or polymeric material present on the lining of the glove). The increased flexibility of the polymeric coating, compared to the coatings of prior art garment material,
20 allows for better dexterity and usability of the gloves.

Gloves made according to the invention were tested for water vapour permeability and absorption of water. The tests were performed on samples taken from four different gloves at a temperature of 20 ± 2 °C and a relative
25 humidity of $65 \pm 2\%$. The thickness of all these samples was 1.08mm. The results of these tests are given in table 1.

For comparison, samples from four prior art gloves were also tested under the same conditions. The prior art gloves were made by using a solution of
30 polyurethane (PU) dissolved in DMF according to the method illustrated in Figure 1. The thickness of each of these samples was 1.03 mm with an area of 18 cm^2 . The results for these tests are given in Table 2.

The water vapour permeability figures are given in units of milligrams of water that pass through a square centimetre of the sample in one hour ($\text{mg.cm}^{-2}.\text{h}^{-1}$). The absorption figures are given in milligrams of water absorbed by the whole sample as measured, with equivalents per square centimetre of the samples in brackets, after set periods of time at a temperature of 20 ± 2 °C and a relative humidity of $65 \pm 2\%$.

Table 1 Test results for samples taken from gloves according to an embodiment of the invention

	Sample 1	Sample 2	Sample 3	Sample 4
Permeability ($\text{mg.cm}^{-2}.\text{h}^{-1}$)	5.77	3.94	6.16	5.38
Absorption (mg.) after 265 minutes	45 (2.5 cm^{-2})	111 (6.2 cm^{-2})	32 (1.8 cm^{-2})	67 (3.7 cm^{-2})
Absorption (mg.) after 400 minutes	44 (2.4 cm^{-2})	143 (7.9 cm^{-2})	28 (1.6 cm^{-2})	69 (3.8 cm^{-2})

Table 2 Test results for samples taken from prior art gloves made using a solution of PU in DMF

	Sample 1	Sample 2	Sample 3	Sample 4
Permeability ($\text{mg.cm}^{-2}.\text{h}^{-1}$)	10.47	10.39	10.47	10.33
Absorption (mg.) after 265 minutes	1 (0.06 cm^{-2})	2 (0.11 cm^{-2})	3 (0.17 cm^{-2})	1 (0.06 cm^{-2})
Absorption (mg.) after 400 minutes	3 (0.17 cm^{-2})	1 (0.06 cm^{-2})	2 (0.11 cm^{-2})	0 (0 cm^{-2})

The average permeability of the samples taken from the gloves according to embodiment of the invention was $5.3 \text{ mg.cm}^{-2}.\text{h}^{-1}$ whereas for the samples taken from the prior art gloves the average permeability was $10.4 \text{ mg.cm}^{-2}.\text{h}^{-1}$.

The tests were performed by an independent test organisation (SATRA Technology Centre, Kettering, Northamptonshire, UK). This organisation uses the following classification for water vapour permeability:

Very High permeability	- over $5.0 \text{ mg.cm}^{-2}.\text{h}^{-1}$
High permeability	- between 2.6 and $5.0 \text{ mg.cm}^{-2}.\text{h}^{-1}$
Moderate permeability	- between 1.0 and $2.5 \text{ mg.cm}^{-2}.\text{h}^{-1}$
Low permeability	- under $1.0 \text{ mg.cm}^{-2}.\text{h}^{-1}$

Therefore, both sets of samples can be considered to have very high permeability (with the exception of sample 2 of Table 1). It can be seen that the permeability of the prior art gloves is much higher than the gloves made according to the method of this invention. However, when the gloves of the current invention are worn there is significantly less build of perspiration than when the prior art gloves are worn. This can be explained by considering the absorption figures: the gloves embodying the invention absorb far more water than the prior art gloves. Therefore, for the gloves embodying the invention, when worn, some of the perspiration is taken from the hand of the wearer and held in the glove and some of the perspiration permeates (i.e. escapes from) the glove, hence there is less perspiration build on the inner surface of the glove. It is believed that the gloves embodying the invention absorb more water because the polymer layer has larger interstitial spaces compared to the prior art due to the method of manufacture of the gloves (i.e., the method of the invention uses foamed polymer which is then washed off, for example with a water spray, before fully coagulating, whereas, for the prior art method the glove

liner/substrate is dipped in a solution of polymer and then immersed in water to coagulate the polymer solution). The interstitial spaces give the gloves a 'wicking action', that is water is pulled into the gloves by capillary action.

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According to a further embodiment of the invention, an array of discrete areas of polymeric material is applied to the surface of the gloves so that it covers areas of the foamed and coagulated polymer to provide a protective coating. For example, this could comprise an array of dots. This coating of
10 polymeric material increases the abrasion resistance of the layer of coagulated polymeric foam. Referring to Figure 10, the dots 102 are applied in an array across the surface of the glove. Additional patches of the coating 104 are applied to particular parts of the surface of the glove, such as between the finger portions and at the fingertips. These are areas
15 that are likely to be subjected to greater wear or abrasion and where larger patches of abrasion resistive coating are particularly valuable.

In the embodiment shown in Figure 10, the dots 102 are circular and spaced evenly across the surface of the glove. The further reinforcing patches 104
20 on the fingertips 106 are in the form of semi-circular strips and a further area is applied between the thumb 108 and the index finger 110. However, it will be appreciated that areas of coating of any shape and size could be applied to a garment. For example, the reinforcing patches on the fingertips could be solid areas of coating and areas could be applied between each
25 finger. The coating could also be applied to garments other than gloves. For example, an area of coating could be applied to the heel of a sock and an array of smaller discrete areas could be applied to the sole.

Figure 11 illustrates the steps of applying the discrete areas of a polymer
30 coating of Figure 10 to the layer of coagulated polymeric foam of a garment. After the gloves have been produced using the method of Figure 3, the foam-coated gloves are washed with a solution of cold water and

detergent at step 310 to remove any residual coagulant left in the glove coating. This removal of any residual coagulant is important for achieving good adhesion between the dots and the foam coating. The gloves may be washed by immersion into a bath/trough of the water and detergent or
5 alternatively, jets of water and detergent may be sprayed onto the gloves through nozzles such as those in spraying station 52 used in an earlier step of glove production. At step 312 the gloves are partially dried at a temperature of between about 50°C and 70°C until damp. The damp condition of the gloves further improves the adhesion of the dots to the
10 foam coating.

In order to apply the dots, the partially dry gloves are dressed onto flat formers, shown at step 314. A dot coating can then be applied at step 316, either manually or using a machine. The thickness of the dot coating
15 applied should be around 0.2-2.0mm. The dotting compound may be one of a number of suitable polymeric materials such as nitrile latex, natural latex, PU latex, latex or a blend of two or more of these and should have a viscosity of about 100 to 400 poise.

20 At step 318 the dotted gloves are cured in an oven, such as oven 44 for a period of between 30 and 45 min at a temperature of 60°C -140°C. Alternatively, the dot coating may be cured in two stages. The first stage comprises 15-30 min at 60°C-80°C and the second comprises 20-40 min at 120°C-150°C. The thickness of the dot coating after curing is reduced to
25 around 0.05-1.0mm. Latex polymers are used because they cure at lower temperatures than the PVC known to be used for the dots on prior art gloves. Latex polymers are also known to have better abrasion resistance than PVC. The final stage of the dotting process, shown at step 320, involves manually stripping the glove from the dot former. The resulting
30 thickness of the foam coating and dot layer of the finished glove is around 0.3-1.8mm.

Figure 12 illustrates the layers of substrate 112, porous coagulated foam 114 and polymeric coating 116. Dots applied to prior art gloves can be easily rubbed off due to the poor bonding between the dots and the coating. However, the porous foam coating 114 of the gloves according to this invention means that material of the dots 116 extends through the pores 118 in the foam 114 and anchors itself to the foam coating 114, improving the bonding between the dots and the coating.

There are a number of parameters controlling the bonding between the liner and the dots. These include:

- i. the formulation of the polymeric material;
- ii. the formulation of the polymeric foam;
- iii. foam density;
- iv. the temperature and time period for curing the dot coating;
- v. the viscosity of the dot coating; and
- vi. weight and construction of the garment or garment material.

It will be appreciated that any of these factors may be varied to achieve the optimum bonding.

CLAIMS

1. A method of making garment material, the method having the steps:
applying coagulant to a substrate;
5 applying a foam of a polymeric material to the substrate;
allowing for the coagulant to coagulate some of the foam; and
removing uncoagulated foam from the substrate to leave a layer of
coagulated polymeric material on the substrate.
- 10 2. The method according to claim 1, wherein the step of removing
uncoagulated foam comprises removing an outer layer of the foam to leave
an inner layer of coagulated polymeric material on the substrate.
3. The method according to claim 2, wherein the outer layer is removed
15 before a skin has formed on the outer surface of the foam layer.
4. The method of any one of claims 1 to 3, wherein the step of removing
the uncoagulated foam comprises directing a fluid at the substrate.
- 20 5. The method of claim 4, wherein the fluid is a liquid.
6. The method of claim 5, wherein the liquid comprises water.
7. The method of claim 5 or 6, wherein liquid is directed as a spray.
25
8. The method of claim 7, wherein the spray has a pressure in the range 1 to
10 bar.
9. The method of claim 8, wherein the spray has a pressure in the range 1 to
30 4 bar.
10. The method of claim 4, wherein the fluid is a gas.

11. The method of claim 10, wherein the gas is at least predominantly air.
12. The method of claim 10 or 11, wherein gas is directed as a jet.
- 5 13. The method of claim 12, wherein the jet has a pressure in the range 1 to 10 bar.
- 10 14. The method of claim 13, wherein the jet has a pressure in the range 1 to 4 bar.
- 15 15. The method of any one of claims 4 to 14 wherein the fluid is directed at angle in the range 0° to 45° to the normal to the surface of the substrate.
16. The method of claim 1, wherein the step of removing uncoagulated foam from the substrate comprises immersing the substrate in liquid.
17. The method of claim 16 wherein the liquid comprises water.
- 20 18. The method of any previous claim wherein the substrate comprises knitted nylon.
19. The method of any one of claims 1 to 17 wherein the substrate is a blend of 95% nylon and 5% lycra.
- 25 20. The method of any previous claim comprising the step of immersing the substrate in water to remove coagulant after the step of removing the uncoagulated foam from the substrate.
- 30 21. The method of claim 20 comprising the step of drying the substrate after the step of immersing the substrate in water.

22. The method of claim 21 wherein the drying comprising placing the substrate in an oven.

23. The method of any previous claim, wherein the step of allowing the
5 coagulant to coagulate some of the foam lasts for a period in the range 60 to 180 seconds.

24. The method of any previous claim, wherein the coagulant is an aqueous solution of one or more electrolytes.

10

25. The method of any one of claims 1 to 23, wherein the coagulant is an alcoholic solution of one or more electrolytes.

26. The method of claim 24 or 25, wherein the one or more electrolytes
15 comprise one or more of the following substances: formic acid, acetic acid, calcium nitrate and calcium chloride.

27. The method of any previous claim, wherein the polymeric material comprises one of: nitrile latex, natural latex, polyurethane latex, polyvinyl
20 chloride latex, neoprene and polyvinylacetate.

28. The method of claim 27, wherein the polymeric material comprises a blend of two or more of: nitrile latex, natural latex, polyurethane latex, polyvinylchloride latex, neoprene and polyvinylacetate.

25

29. The method of any previous claim, wherein the substrate is placed on a mould before the coagulant is applied to the substrate.

30. The method of claim 29 wherein the mould is composed of one or more
30 of the following materials: metal, ceramic, fibre glass and plastic.

31. The method of claim 29 or 30, wherein the mould takes the form a portion of a garment.

5 32. The method of claim 29 or 30, wherein the mould takes the form of a complete garment.

33. The method of any previous claim, wherein the garment is a garment chosen from one of the following: a coat, an apron, a boot, a shoe, a sock, an item of underwear, a glove, and a corset.

10

34. The method of any previous claim, further comprising the step of applying a coating in an array of discrete areas to the layer of coagulated polymeric material.

15 35. The method of claim 34 further comprising at least one of the steps of:
washing the garment or garment material to remove residue;
partially drying the garment or garment material; and
dressing the garment or garment material on an array former before
applying the coating; and then
20 curing the layer of coating; and
stripping the garment or garment material from the array former.

36. The method according to claim 35, wherein a solution of water and detergent is used to wash the garment or garment material.

25

37. The method of claim 35 or claim 36, wherein the garment or garment material is partially dried at a temperature of around 50-70°C.

38. The method of any one of claims 34 to 37, wherein the layer of coating
30 comprises one of or a blend of two or more of nitrile latex, natural latex, PU latex and latex.

39. The method of any one of claims 34 to 38, wherein the viscosity of the layer of coating is around 100-400 poise.
40. The method of any one of claims 34 to 39, wherein the layer of coating is cured for 30-45 min at 60-140°C.
41. The method of any one of claims 34 to 39, wherein the layer of coating is cured in two stages, the first stage comprising 15-30 min at 60-80°C and the second stage comprising 20-40 min at 120-150°C.
42. The method of any of claims 34 to 41 wherein the array of discrete areas of coating comprises an array of dots.
43. The method of any of claims 34 to 41 wherein the array of discrete areas of coating comprises a combination of an array of dots and strengthening patches.
44. A garment material produced by the method of any preceding claim.
45. The garment material of claim 44 having a water vapour permeability in the range 3.5 to 6.5 mg.cm⁻².h⁻¹.
46. The garment material of claim 44 or claim 45, when subjected to a temperature of 20± 2 °C and a relative humidity of 65±2% for 265 minutes, holding between 1.0 mg and 8.5 mg of water per cm² of the garment material.
47. A garment produced by the method of any one of claims 1 to 43.
48. The garment of claim 47 having a water vapour permeability in the range 3.5 to 6.5 mg.cm⁻².h⁻¹.

49. The garment of claim 47 or claim 48, when subjected to a temperature of 20 ± 2 °C and a relative humidity of $65 \pm 2\%$ for 265 minutes, holding between 1.0 mg and 8.5 mg of water per cm^2 of the garment.

5 50. The garment of any one of claims 47 to 49, wherein the garment is a glove.

51. A garment or garment material having a substrate and a layer of coagulated polymeric material penetrating at least partially the substrate,
10 wherein the garment or garment material has a water vapour permeability in the range 3.5 to 6.5 $\text{mg} \cdot \text{cm}^{-2} \cdot \text{h}^{-1}$.

52. The garment or garment material of claim 51, when subjected to a temperature of 20 ± 2 °C and a relative humidity of $65 \pm 2\%$ for 265 minutes,
15 holding between 1.0 mg and 8.5 mg of water per cm^2 of the garment or garment material.

53. A garment or garment material having a substrate and a layer of coagulated polymeric material penetrating at least partially the substrate,
20 wherein the garment or garment material, when subjected to a temperature of 20 ± 2 °C and a relative humidity of $65 \pm 2\%$ for 265 minutes, holds between 1.0 mg and 8.5 mg of water per cm^2 of the garment or garment material.

25 54. A garment or garment material having a substrate and a layer of coagulated polymeric material penetrating the substrate, wherein the polymeric material does not fully penetrate the substrate.

55. The garment or garment material of any of claims 51 to 54 further
30 comprising a layer of dots formed from polymeric material bonded to the layer of coagulated polymeric material.

56. A garment or garment material having a substrate and a layer of coagulated polymeric material penetrating at least partially the substrate, wherein bonded to the layer of coagulated polymeric material is a layer of dots formed from polymeric material.

5

57. The garment or garment material of any one of claims 51 to 56, wherein the garment is a glove.

58. Apparatus for producing garment material comprising a mould arranged
10 to support a substrate, foam application means arranged to apply foam of a polymeric material to the substrate, and foam removing means arranged to remove uncoagulated foam from the substrate to leave a layer of coagulated polymeric material on the substrate.

15 59. Apparatus according to claim 58, further comprising dot application means arranged to apply a dot coating to the layer of coagulated polymeric material.

20 60. Apparatus according to claim 59, further comprising at least one of washing means arranged to remove any residue from the garment material, drying means arranged to partially dry the washed gloves, and curing means arranged to cure the dot coating.

25 61. A method as hereinbefore described with reference to Figures 3 and 4.

62. An apparatus as hereinbefore described with reference to Figure 4.

63. A garment as manufactured according to the method as hereinbefore described with reference to Figures 3 and 4.

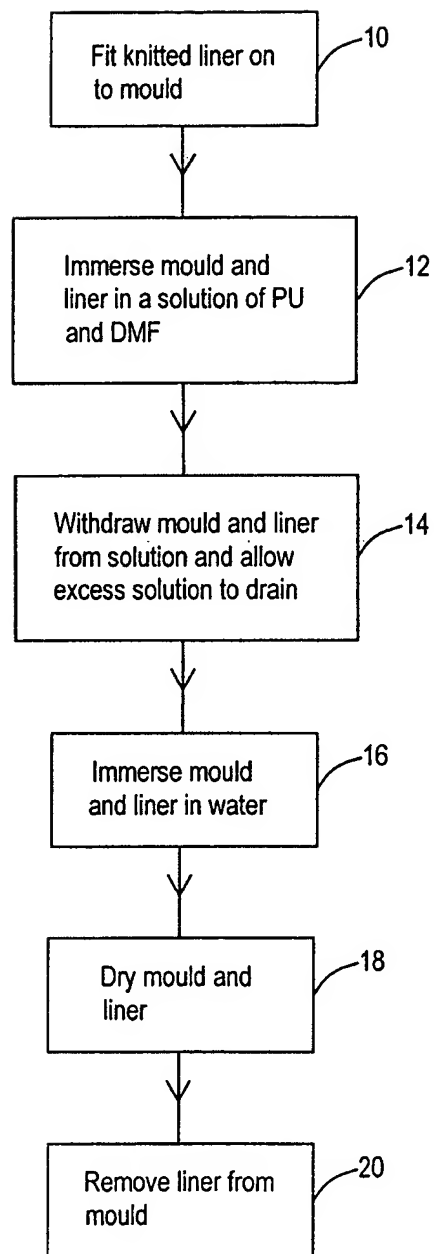
ABSTRACT**POLYMERIC GARMENT MATERIAL**

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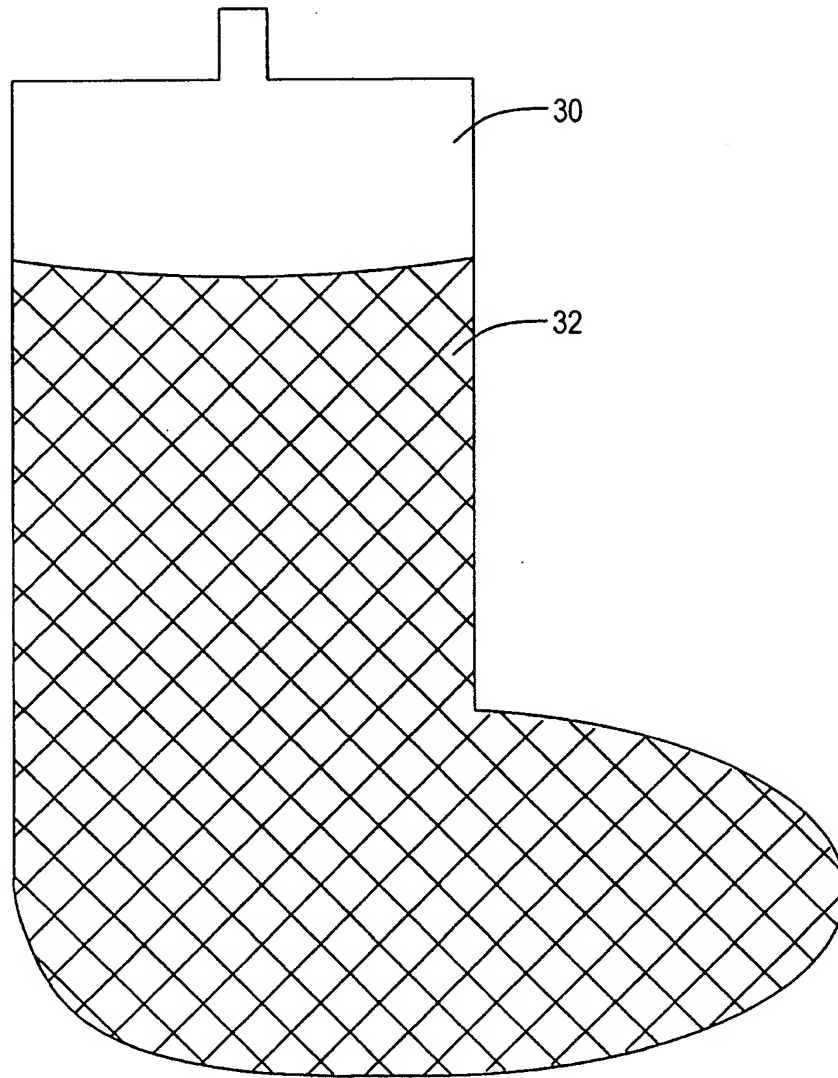
A method of making garment material, the method having the steps:
applying coagulant (34) to a substrate (32); applying a foam (38) of the
polymeric material to the substrate (32); allowing the coagulant (34) to
10 coagulate some of the foam (38); and removing uncoagulated foam (38)
from the substrate (32) to leave a layer of coagulated polymeric material on
the substrate (32).

To be accompanied by Figure 4 when published

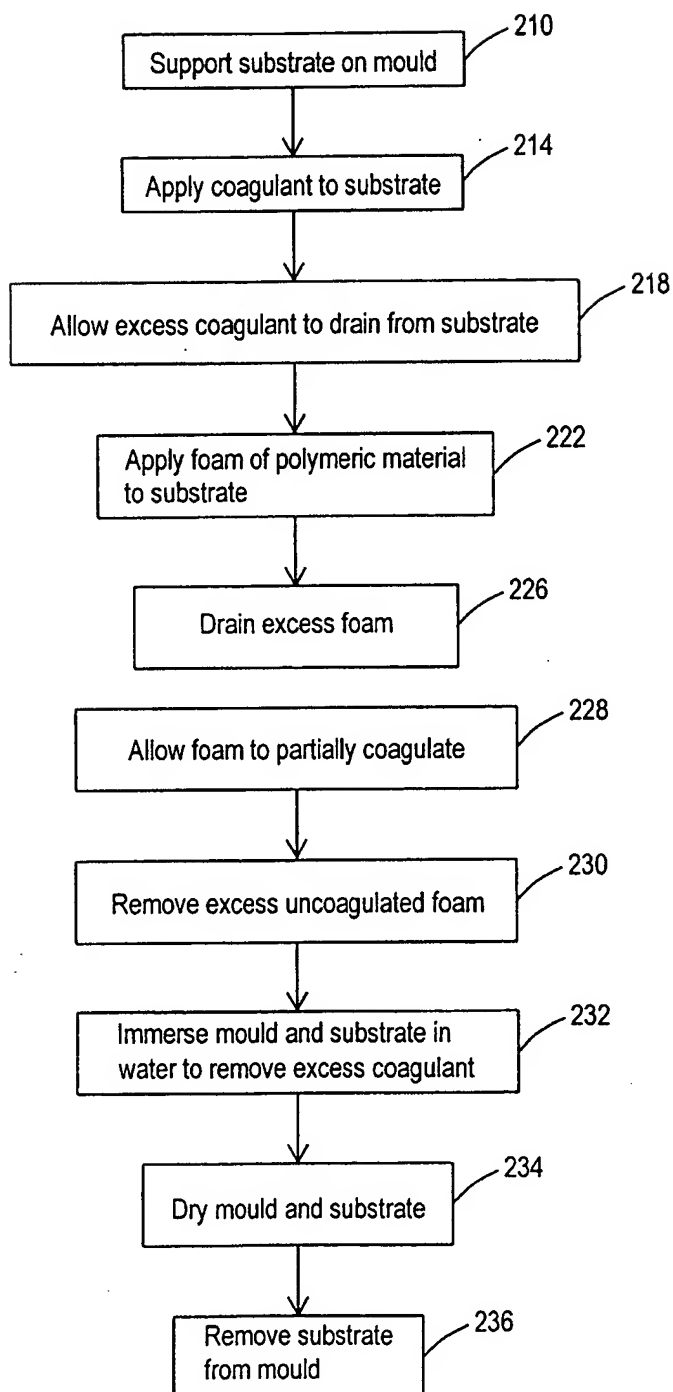
1/7

*Fig.1*

2/7

*Fig. 2*

3/7

*Fig.3*

4/7

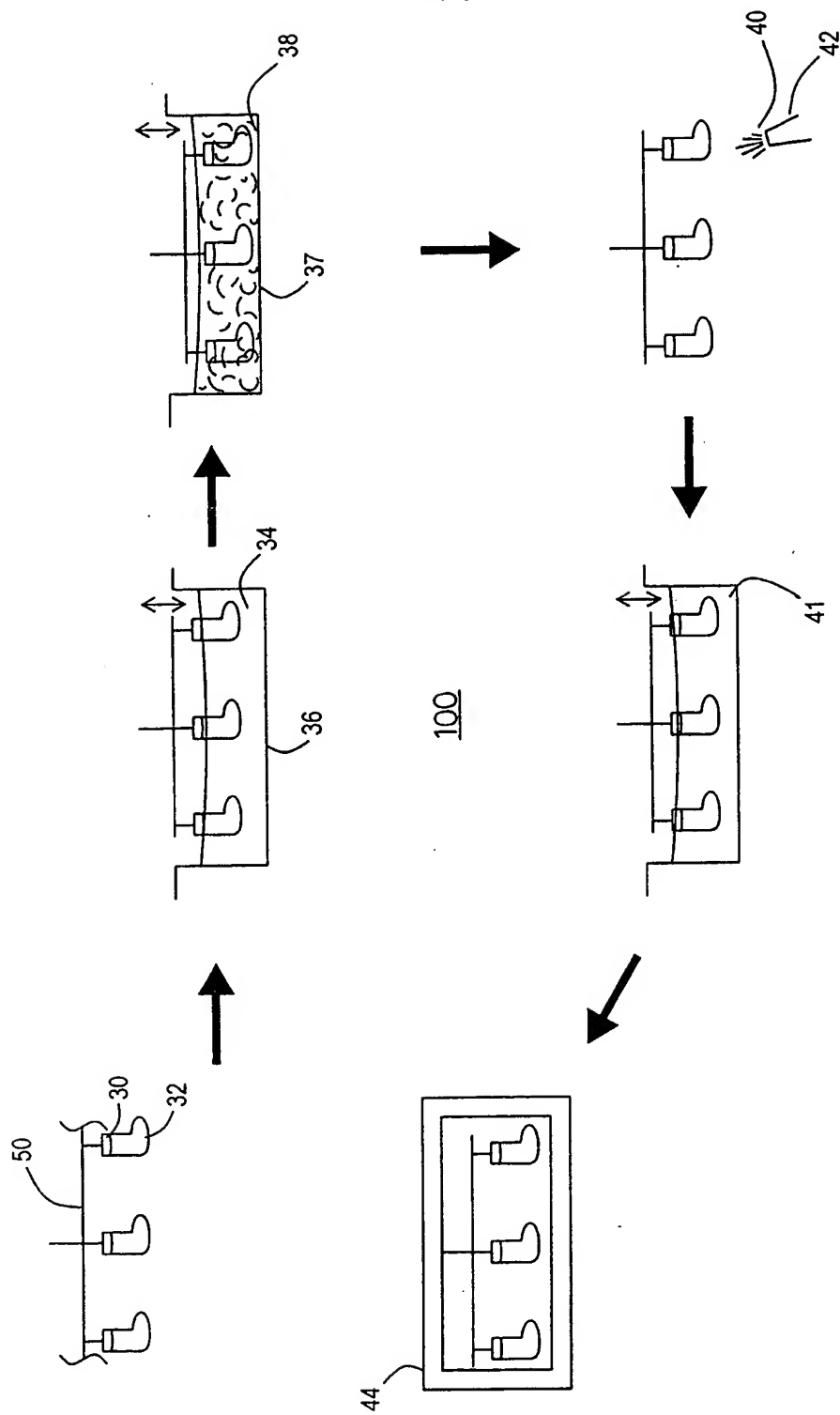


Fig. 4

5/7

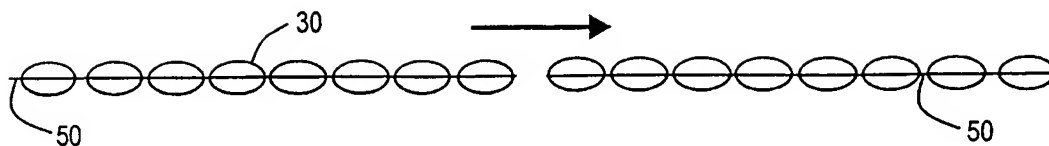


Fig. 5

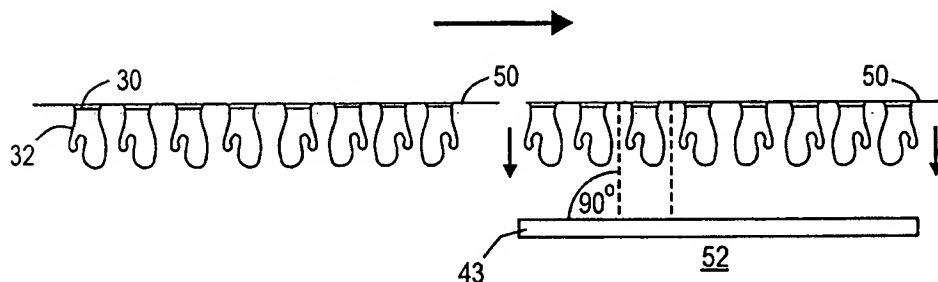


Fig. 6

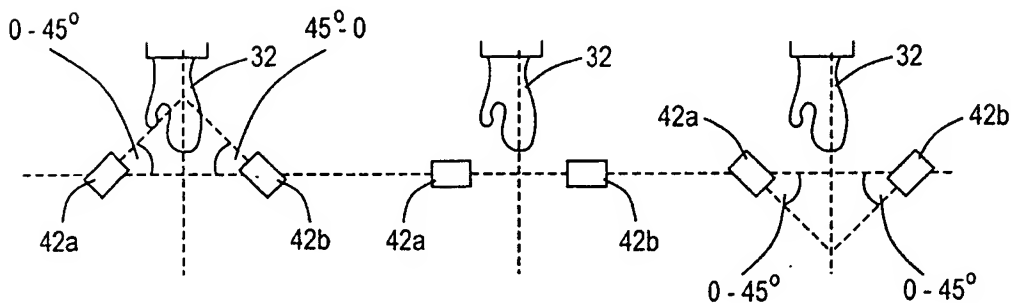
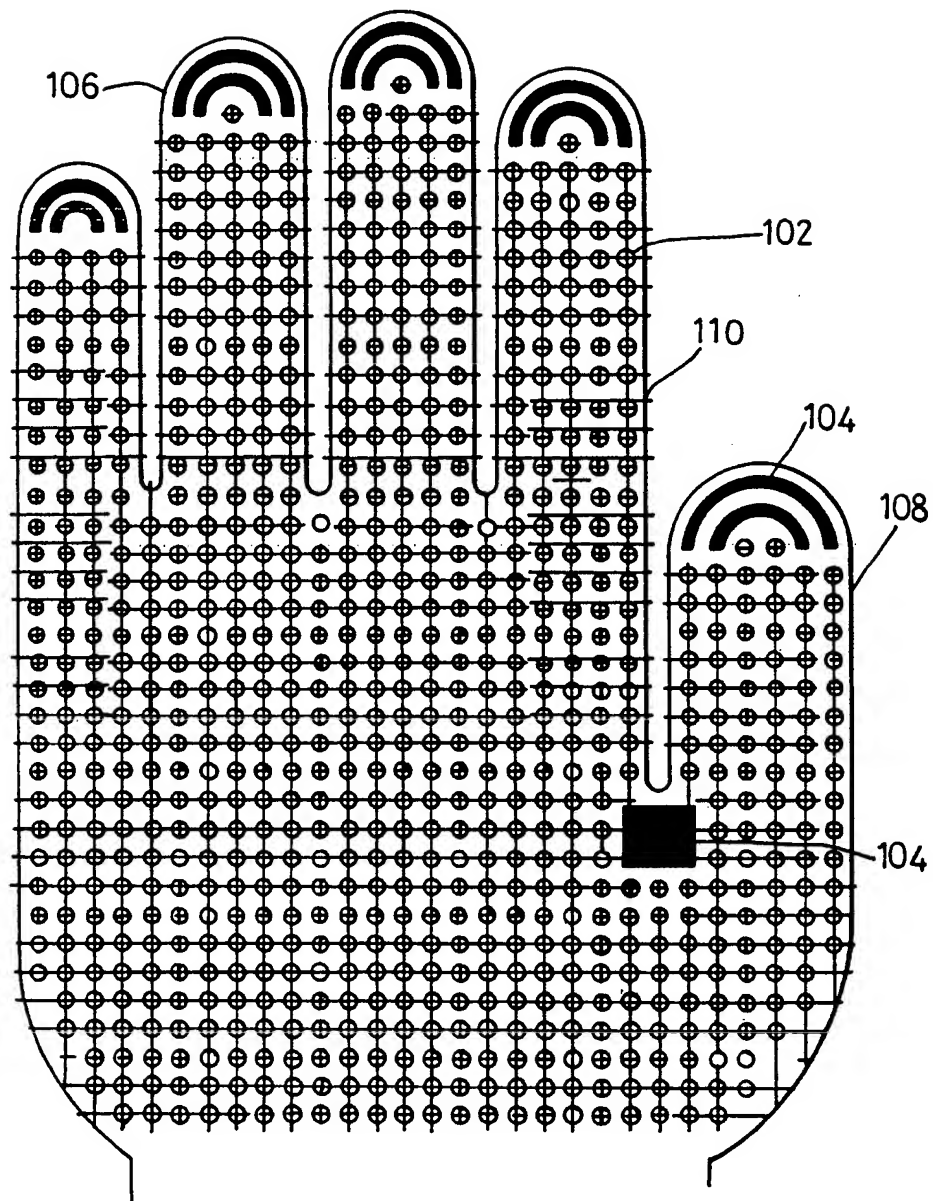


Fig. 7

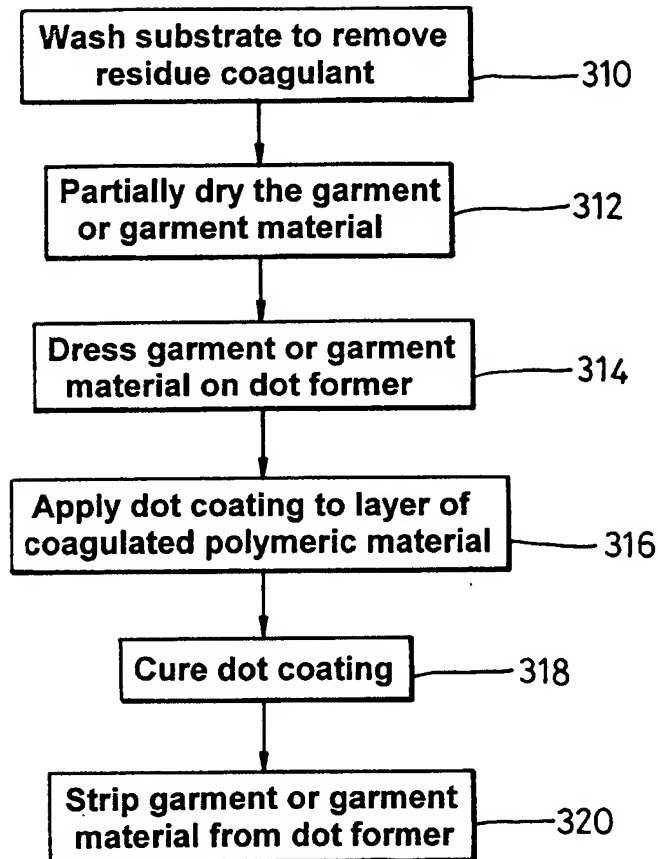
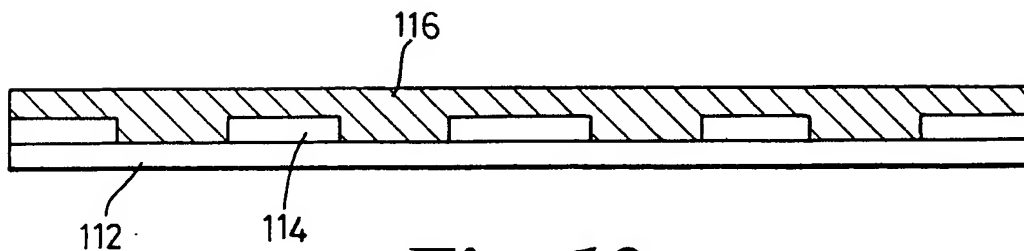
Fig. 8

Fig. 9

6/7

*Fig. 10*

7/7

*Fig. 11**Fig. 12*